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Exploring Data Analytics in Attendance Systems: Unveiling Machine Learning Techniques, Patterns, Practices, and Emerging Trends

Joseph Teguh Santoso[1*], Danny Manongga[2], Iwan Setyawan[3], Hindriyanto Dwi Purnomo[4], Hendry[5]
[1,2,3,4,5]Department of Informatics, Faculty of Information Technology, Satya Wacana Christian University, Indonesia

Abstract.
Purpose: The research aims to identify patterns and trends in attendance management through the application of reward and punishment systems as innovative solutions for improving employee attendance and well-being.
Methods: This research utilizes a descriptive analysis approach with the application of Machine Learning (ML) techniques to enhance the accuracy of attendance pattern prediction and ML models for the classification of emerging trends and patterns. Research data were obtained through the company's attendance system and divided into two segments (80% for training and 20% for testing) while maintaining a balanced class proportion, then processed using SPSS and Python software with the Scikit-learn library.
Result: The results of the study show that employee attendance is increased from 86.52% to 90.44% when the reward and punishment method is applied to the employee attendance system. Proper reward allocation can increase employee motivation to adhere to work schedules and consistently attend, while punishment tends to lead to lower attendance rates.
Novelty: This research emphasizes the optimization of attendance management through data analytics approaches and the implementation of advanced technology in attendance systems with the application of ML techniques to analyze attendance data comprehensively and detect significant patterns.

Keywords: Attendance management, Reward and punishment, Data analytics, Implementation of technology in attendance systems
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INTRODUCTION

In today's increasingly competitive business era, attendance management plays a crucial role in enhancing company productivity. Low employee attendance rates will directly impact overall company performance, ultimately resulting in decreased productivity and unforeseen additional costs [1], [2], [3]. In addition to these impacts, work culture and inter-staff motivation will decline. Hence, a profound comprehension of the significance of attendance oversight within contemporary business landscapes is imperative to safeguard the enduring prosperity of the enterprise. Although it is a common practice in many organizations, traditional attendance poses various challenges in achieving attendance efficiency—for example, errors in recording, employee tardiness, and complex bureaucracy. Moreover, manual attendance systems are prone to data manipulation, which can lead to incorrect decisions and affect the overall productivity of the company. Therefore, more sophisticated solutions are needed to address these challenges. In this context, modern technologies like face recognition systems offer significant potential to reshape attendance management. These systems promise higher accuracy, operational efficiency, and enhanced data security. According to [4], [5], [6], [7], [8], [9], companies can avoid common errors in manual processes and reduce the time needed to track and record employee attendance when using technology in attendance systems. However, adopting new technology will inevitably bring about new challenges as well, including cultural changes and employee readiness to adopt these new technological changes. Therefore, it is crucial to grasp the complete ramifications of incorporating facial recognition systems within existing business contexts and how companies can effectively prepare for these changes.

Previous studies have tended not to conduct comprehensive analyses of employee attendance patterns or implement advanced technology in attendance systems to improve human resource management. Kumari

*Corresponding author.
Email addresses: joseph_teguh@stekom.ac.id (Santoso)
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et al. [10] and Cai et al. [11] investigated employee presence in the workplace and discovered that rewards and motivation had a significant positive impact on employee performance; however, this study did not specifically examine the impact of the company's presence system on employees. Similarly, a study by Abdullah [12] investigated the effectiveness of the implementation of the presence system in health sector companies and found that flexibility of schedules, clarity of presence policies, and management support were key factors that influenced employee compliance with presence systems. However, the study did not look into the impact of human variables like individual motivation on staff presence. This is consistent with Suale et al. [13], who adopted an attendance system using money as an incentive. However, their study found no significant direct effect on employee wages and only minimal impact on the management level of employees. Therefore, this research aims to fill these knowledge gaps by conducting a comprehensive descriptive analysis to gain a deeper understanding of the factors influencing employee attendance and the effectiveness of the company's attendance system. Furthermore, the study promises to provide new insights by utilizing advanced analytical tools to reveal complex presence trends among employees. The research adopts a data-gathering technique that incorporates many versions inside the business, allowing for a comprehensive investigation of patterns of presence. This study will be distinguished from prior research efforts by a novel feature selection strategy that uses Machine Learning (ML) algorithms to detect tiny changes in employee presence behavior. This study will provide improved insight to firm management by analyzing precise presence data to increase employee discipline, productivity, and well-being, as well as develop a disciplined working culture. Furthermore, the study integrates presence management and data analysis to provide a comprehensive strategy for improving employee presence management. Within the framework of this research, a face recognition-based attendance system was implemented as an integral part of broader employee management initiatives. This system is not only used to record employee attendance more accurately and efficiently but is also integrated with a reward and punishment system. This approach aims to create clear incentives for employees to adhere to company attendance policies and strengthen a culture of discipline in the workplace. Through detailed attendance data analysis, this research identified the impacts and emerging patterns during the study period, and the data was analyzed deeply to provide better insights to company management in making evidence-based decisions to enhance employee discipline, productivity, and well-being. Furthermore, this research also contributes to the integration of attendance management and data analytics, where it will combine attendance management and data analytics to present a holistic approach to optimizing employee attendance management.

The concept of attendance management is an approach applied by companies to manage and monitor employee attendance in the workplace environment. Simply put, attendance management encompasses a series of policies, procedures, and practices designed to ensure that employees are present at work according to the prescribed schedule. According to [1], [14], [15], [16], attendance management plays a crucial role in maintaining operational stability for companies because high attendance levels contribute to better productivity, consistent performance, and a positive work culture. In this regard, various factors influence attendance, one of which is employee well-being. Research from [2], [17], [18], [19], [20], [21] examine the significance of both the physical and mental welfare of employees in shaping their presence and engagement within the workplace. According to them, employees who feel healthy and happy tend to have higher attendance rates. Additionally, factors such as weather conditions, transportation issues, and personal problems can also affect employee attendance at work. In addition to individual well-being, organizational factors also play a significant role in attendance management. Company policies related to work schedules, work flexibility, and leave policies influence employee attendance levels. [22], [23], [24], [25], [26], [27] demonstrate that flexible policies that support work-life balance can improve attendance discipline among employees. On the other hand, strict and less flexible policies can lead to stress and dissatisfaction, thus negatively impacting employee attendance. Therefore, companies need to carefully consider the policies they implement to ensure they support consistent and productive employee attendance. Apart from organizational factors, external factors can also influence employee attendance. For example, unstable economic conditions affecting employees, industry trends such as the adoption of new technologies in companies, and changes in job demands can affect their stress levels and job satisfaction. By understanding these factors, companies can take appropriate steps to improve employee attendance and create a more productive and sustainable work environment.

According to [28], [29], [30], [31], [32], face recognition-based attendance systems enable automatic face recognition, reducing physical interaction, and replacing time-consuming attendance cards or keys, thereby simplifying and expediting the attendance process. The main advantage of using face recognition systems in attendance management is increased accuracy and security. Through this technology, employee

identification can be done quickly and accurately, reducing the risk of errors in data recording and manipulation. According to Gode [33], the accuracy of face recognition systems reaches a very high level, even in less-than-ideal lighting conditions or changes in a person's physical appearance. Despite having various advantages, the use of face recognition systems in attendance also faces certain challenges. One of them is privacy and data security issues. Research by [29], [33], [34], [35], [36], [37], [38] highlight issues related to the collection and use of sensitive biometric data on employee faces. This raises ethical questions about how the data is stored, accessed, and protected from misuse or security breaches. In addition to these challenges, there are also technical challenges, such as difficulties in dealing with variations in human facial appearances. [28], [39], [40] indicate that the system is susceptible to identification errors when facing variations in lighting, facial expressions, or natural physical changes. Therefore, the development of more advanced and responsive technology is necessary to tackle these obstacles and enhance system efficiency. However, despite the challenges associated with the use of face recognition systems, the potential benefits in attendance management are evident. [41], [42] show that the use of this technology can result in significant cost savings for companies, as seen from the need for physical infrastructure such as attendance machines or identity cards, which can save significant costs. Additionally, the system can enhance user experience by speeding up the attendance process and reducing the time spent by employees on administrative procedures. Thus, although challenges related to the use of face recognition systems exist, their potential benefits in attendance management make them an attractive solution for many organizations.

Machine Learning (ML) techniques have become a popular approach in addressing problems and identifying hidden patterns. In this research context, it pertains to attendance data. Through ML algorithms, companies can analyze employee attendance data holistically and detect anomalies as well as significant patterns. For instance, Mallikarjunaradhya [43] demonstrated that using ML techniques such as clustering can enhance accuracy in predicting certain patterns, enabling proactive decision-making. Although not in the industrial field, however, Mallikarjunaradhya [43] utilized clustering models from ML to predict diseases and cancer in the healthcare domain. Meanwhile, Ozcan [44] combined classification and regression models from ML techniques to create models and predictions on heart diseases. The importance of employing ML techniques is also elucidated by [45] and [46], highlighting the significance of using ML techniques in analyzing and predicting employee performance within a company. Through the use of regression algorithms and advanced data processing, this research will generate predictive models capable of identifying emerging patterns, especially in attendance, which are correlated with various external variables impacting the company in planning more effective human resource management strategies. Meanwhile, [14] and [47] explore the integration of ML techniques in performance optimization, recruitment systems, and employee attendance systems. By combining ML techniques, predictive models can accurately generate insights to predict emerging patterns in research based on the physical work environment. This indicates that this approach allows companies to effectively identify unexpected patterns and take appropriate corrective actions, thus enhancing overall productivity and operational efficiency.

METHODS

The population consists of all employees registered in the company's attendance system. In sample selection, a stratified random approach was used to ensure that the sample taken reflects the diversity of the company's employees. This process was carried out to ensure a good representation of various levels, departments, and positions within the company so that the research results can be more widely applicable. Next, the collection of attendance data was done directly through the face recognition system that has been implemented in the company. Data collection steps were taken with official permission from the company to access and analyze employee attendance data. Official permission was also obtained to ensure compliance with applicable privacy regulations and data protection. Attendance data consisted of records of employee attendance and departure recorded periodically over 11 months. The data collection process also took place over 11 months, during the initial period of the year starting from February to December, where rewards and punishments were administered in 7 months, while the remaining 4 months were used to analyze patterns, trends, and factors influencing employee attendance, as well as to analyze the impact on employees after rewards and punishments were applied.

The gathered data includes important information such as date, time, late days, the number of late occurrences per employee every week, duration of lateness, and identification of employees who are present or late (using employee codes without names to maintain anonymity and protect employees' data). Additionally, additional information such as the department or position of employees can also be included

for deeper analysis related to specific factors influencing attendance. During the data collection process, strict data security measures were implemented to protect employee privacy and company data security. This included the use of data encryption, restricted access only to authorized personnel, and compliance with privacy policies set by the company. Emphasis were placed on adhering to privacy mandates such as the GDPR (General Data Protection Regulation) to uphold the secure handling and ethical processing of employee attendance data. Following the acquisition of necessary data, analysis ensued utilizing statistical methodologies and pertinent data analysis techniques aligned with the research objectives. This entailed employing statistical software and data analysis tools to discern patterns, trends, and interrelationships among variables inherent in the attendance data. Furthermore, the analysis results were generalized to the research findings to develop recommendations that could be implemented by company management to improve attendance management and employee well-being.

Identification of attendance patterns using machine learning techniques

To identify employee attendance patterns using ML techniques, several steps were involved. The process of identifying employee attendance patterns using ML techniques can be seen in Figure 1. In data processing, data such as employee attendance including time information, date of attendance, type of absence, and various other factors, was prepared and collected first. Afterward, the data was cleaned to handle missing values or invalid values. In this case, normalization was performed if necessary. The next step was feature extraction, where various relevant features from the attendance data were identified to describe attendance patterns such as the number of days absent or present per week and month or during specific periods. The technique used for the extraction feature in this study is Principal Component Analysis (PCA). This technique was chosen because it is sufficiently effective to deal with asbestos data with many features and attributes so that its structure can be simplified into several major components that most influence the variation of available data [48]. It also helps in accelerating the analysis process, eliminating reliance on less relevant features, and enabling focus on the features that are most important or influential in explaining employee presence patterns. Besides, this technique is assessed to help reduce the complexity of the model and speed up the training process. In this context, additional features influencing employee attendance at the company (e.g., weather, traffic congestion, holidays, etc.) were considered. In the next stage, several ML models were applied. In this case, the ML models used were clustering and classification. In clustering ML, K-Means was used to group employees based on attendance patterns so that similar attendance patterns could be well identified. Meanwhile, for classification ML, Naïve Bayes, Decision Tree, and Support Vector Machines (SVM) based on specific variable attendance levels were utilized. In terms of ML models, it is very common to be used as a classifier in various fields, including in the context of prediction [49], [50], [51], [52], [53], [54], [55], [56]. In the next step after implementing ML techniques, training and evaluation were carried out, where data were divided into two using random data splitting, namely 80% for training and 20% for testing. This was done in the Scikit-learn library using Python, which supports ML techniques, randomly selecting rows of data to be included in the training and testing sets while maintaining a balanced class proportion. To train the model and evaluate the performance of each data, evaluation metrics such as accuracy, precision, recall, and F1-score were used. Finally, data interpretation was conducted, where the results of the model were interpreted to understand the discovered employee attendance patterns. This was further used to take appropriate actions, such as identifying factors influencing attendance rates and designing effective attendance management strategies.

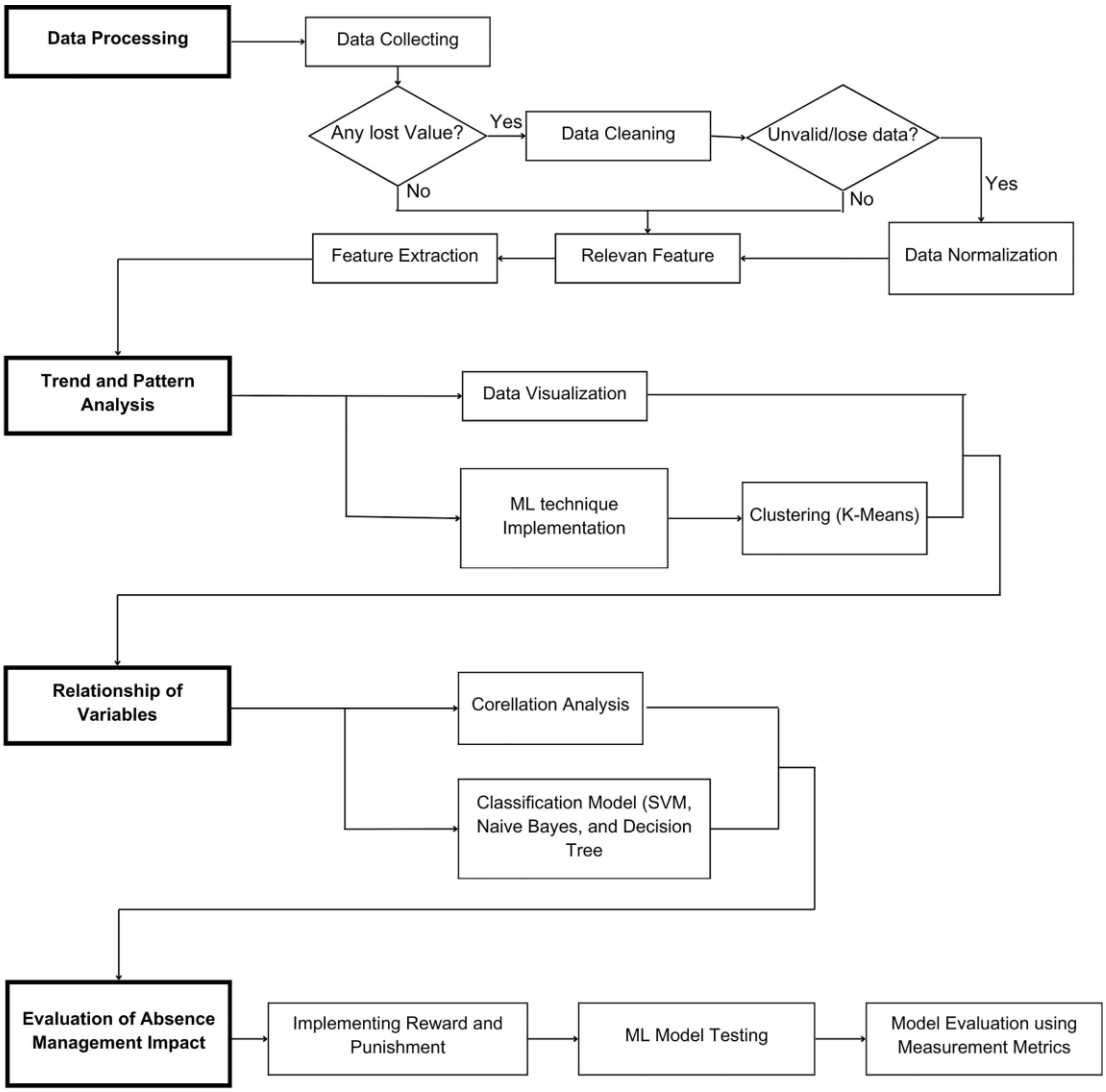

Figure 1. Identification of employee attendance patterns and trends using PCA feature extraction technique (author's elaboration)

Variable

The main focus of research variables in the analysis of employee attendance data includes two important aspects: clocking in and clocking out, as well as the types of rewards and punishments applied as part of the company's attendance management system. The first variable, clocking in and out, refers to the records of employee's presence at the workplace, both at the beginning and the end of the workday. According to Rana [57], an in-depth analysis of attendance patterns can provide valuable insights into employees' compliance with work schedules and the factors influencing them. Furthermore, the second variable is the type of rewards and punishments applied to enhance employee work discipline. Rewards can take the form of incentives, recognition, or bonuses given to employees who adhere to work schedules well or have high attendance rates. On the other hand, punishments can include fines, penalties, or other sanctions imposed on employees who are frequently late or absent without valid reasons. [10], [11], and [58] highlight the importance of understanding the effectiveness of rewards and punishments in motivating employees and improving discipline in the context of attendance management. In the present study, the rewards given to employees are bonuses awarded to diligent and disciplined employees, while punishment takes the form of bonus deduction. There are two bonus periods each year, namely mid-year and end-of-year, with a small bonus for each employee. However, with this reward-punishment system, diligent employees will receive additional bonuses from the deduction of bonuses due to punishment that other employees receive. This can happen if employees are consistently late or absent or even fail to clock in daily. Both of these variables

are considered important indicators in evaluating the effectiveness of the company's attendance management system. Eventually, the types of rewards and punishments applied will provide an overview of how these incentives or sanctions affect employee attendance and discipline. In the data analysis process, these two variables were measured and evaluated separately to understand their impact on overall employee attendance.

Hypothesis

In K-Medoids, the cluster representatives are known as "medoids," which are positioned centrally within their respective clusters and are less influenced by outliers. The clustering process includes assessing the distance between medoids and other objects, with Figure 2 showing the computational steps of the K-Medoids method [59].

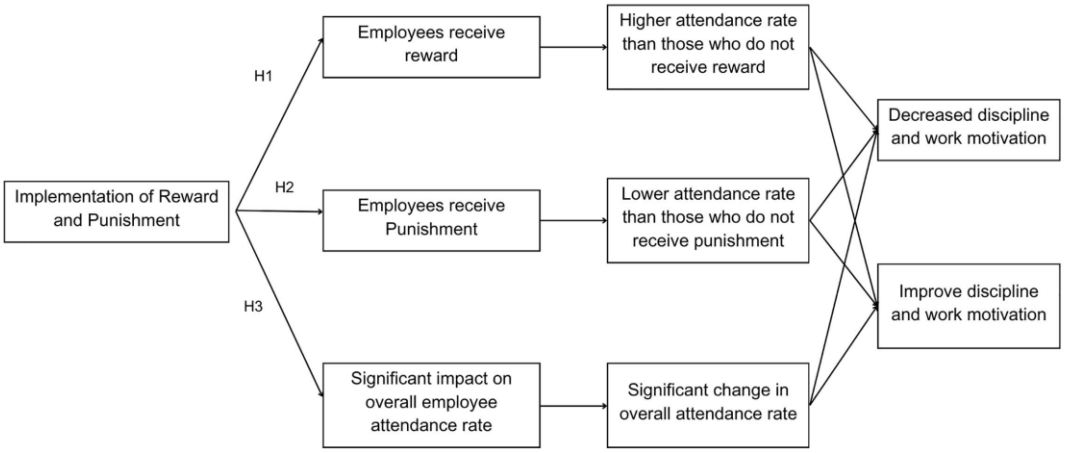

Figure 2. Research hypothesis (author's elaboration)

There are three interrelated hypotheses in this study, where the relationship between hypotheses and findings can be seen in Figure 2.

H1: *Employees who receive rewards have a higher attendance rate than employees who do not receive rewards.*

H2: *Employees who receive punishments have a lower attendance rate than employees who do not receive punishments.*

H3: *The implementation of reward and punishment systems in attendance management have a significant impact on the overall attendance rate of employees.*

Data analysis

The data analysis technique used was descriptive analysis to provide an overview of attendance data, including analysis methods using ML. Through this technique, employee attendance patterns can be identified, such as average attendance rates, frequency of lateness, and distribution of attendance by day. [59], [60], and [61] demonstrate that descriptive analysis is an important initial step in understanding the basic characteristics of attendance data, which can then be used as a basis for further analysis. The data analysis software used in this research was SPSS, for processing attendance data in more detail. This included frequency analysis using ML (classification and clustering), recall, precision, accuracy, F1-score calculations, variance analysis, and hypothesis testing. Python with Scikit-learn as its library was also utilized. Python was chosen for its ability to handle large and complex data, as well as its flexibility in creating custom algorithms. With the assistance of these statistical software, a deeper analysis can be conducted to identify factors influencing employee attendance and test research hypotheses. According to Acosta [63], the use of statistical software provides greater flexibility and accuracy in data analysis, allowing researchers to explore relationships between variables more effectively. To calculate the mean, median, and standard deviation of employee attendance data, this research used data obtained from the respective company and each was calculated using Mean, Median, and Standard Deviation. Where, Mean was used to calculate the average attendance percentage of employees, where all attendance percentages were summed and then divided by the total number of employees in Equation 1.

$$\text{Mean}=\frac{\text{Total attendance percentage}}{\text{Number of employees}} \quad (1)$$

In this case, the total number of employees under study is 200. Meanwhile, the Median is the middle value of the data when sorted from smallest to largest. And finally, Standard Deviation was used to measure how far data are spread from the mean in Equation 2.

$$\text{Standard Deviation}=\frac{\sqrt{\sum(\text{Data-Mean})^2}}{\text{Number of employees}} \quad (2)$$

Meanwhile, for the ML models in this study, several algorithms were used for clustering and classification. For clustering, K-means was utilized, where the data was divided into k different clusters. This involved finding the centroid for each cluster and then reassigning data points to the nearest centroid. The formula for calculating the distance between these points is:

$$\text{Centroid } (c_i)=\frac{1}{|s_i|}\sum x_j \in S_t X_j \quad (3)$$

$$\text{Euclidean Range } (d(x_i, c_j)=\sqrt{\sum_{l=1}^{n}(x_{il}-c_{jl})^2} \quad (4)$$

where c_i is the centroid of group i, which represents the central point of the data group in feature space, while $|S_i|$ is the total data points in the group. The Euclidean distance between point x_i and c_j is interpreted using $d(x_i, c_j)$, which is the distance metric used in K-Means to measure how close or far a data point is from the centroid of a group. For classification in this case, it consists of three ML models, namely SVM, Naïve Bayes, and Decision Tree, each of which has formulas as follows:

$$\text{SVM}=f(x)=w\times x+b \quad (5)$$

where w is the weight vector, x is the feature vector, and b is the bias. Meanwhile, for the Naïve Bayes algorithm, it used Bayes' theorem to calculate the probability of classes based on attributes.

$$P(C_k|X)=\frac{P(X|C_k)P(C_k)}{P(X)} \quad (6)$$

where C_k is a class, X is a feature vector, $P(C_k|X)$ is the prior probability, and $P(X)$ is the evidence. In this case, each algorithm has a different mathematical formulation depending on the principles and specific steps performed in that algorithm.

RESULTS AND DISCUSSIONS

Data processing and feature extraction

Data extraction results include employee presence patterns, presence characteristic relationships, influences of external factors, time trends, and employee groups. The results of the extraction showed the presence of patterns of employee presence variability such as certain days where presence was higher or lower than average. The result also showed that there was a relationship between the presence feature and a pattern of absence, indicating consistency at a certain time in a week. In addition to the two results, other results are influenced by external factors such as weather, traffic jams, or holidays. The pattern shows increased absences when the weather is good and counted as bad if there is congestion on certain days. In the current trend, there are also rises and falls with a duration of approximately four consecutive months. Finally, there is a grouping of employees, where these are grouped according to the presence patterns resulting in identifying groups of employees who have similar presence models and probably require similar management strategies anyway.

Description analysis of attendance data

The findings reveal that the mean punishment level administered is 2.3, with a standard deviation of 0.5. Moreover, the mean duration of employees' check-in occurrences is 7.8 days, with a standard deviation of 1.2, whereas the mean duration of employees' check-out occurrences is slightly higher at 7.9 days, presenting a standard deviation of 1.4. The company's work schedule is 35 hours per week, with a standard deviation of 5.0, and the average working hours per day are 7 hours, with a standard deviation of 1.5. The

prevalent form of incentive displays an average rating of 1.5, accompanied by a standard deviation of 0.3. Regarding the outcomes of the dependent variables, the company's productivity exhibits an average score of 85, with a standard deviation of 10.0. Employee attendance quality is rated at 4.2, denoting a standard deviation of 0.6. The mean employee attendance rate stands at 90.44%, while employee discipline garners an average rating of 3.8, accompanied by a standard deviation of 0.4. Furthermore, the average duration of lateness is 10 minutes, exhibiting a standard deviation of 2.5, and the average duration of absence totals 3 days, with a standard deviation of 1.2.

Table 1. Mean and standard deviation results for research variables (author's elaboration)

Independent/Dependent Var.	Mean	Std. Deviation
Type of punishment	2.3	0.5
Type of reward	1.5	0.3
Clock in	7.8	1.2
Clock out	7.9	1.4
Work schedule	40	5.0
Working hours	8	1.5
Company productivity	85	10.0
Attendance quality	4.2	0.6
Attendance rate	90.44%	-
Employee discipline	3.8	0.4
Lateness	10	2.5
Absence	3	1.2

Table 2. Summary of research findings (author's elaboration)

No.	Variable and Indicator	Finding Description
1.	General employee attendance statistics	• Average Attendance: 90% • Attendance Distribution: Majority of employees are punctual. • Lateness Distribution: A small portion of employees have a high rate of lateness.
2.	Attendance policies	• Policy Effectiveness: Attendance and work discipline policies are generally effective in maintaining high attendance rates. • Special Attention: There are still a small number of employees who require special attention in work discipline and punctuality in attendance. • Identification of Improvement Areas: Attendance and lateness patterns and distributions are used to identify areas needing improvement. • Implementation of Additional Strategies: Implementation of additional strategies is recommended to enhance performance and work discipline.
3.	Evaluation of the effectiveness of rewards and punishments	• Positive Correlation between Reward and Attendance Rate: Employees who receive rewards have a higher attendance rate, thus, their motivation to work is also high. • Negative Correlation between Punishment and Attendance Rate: Employees who receive punishment have a lower attendance rate.
4.	Comparison analysis between groups receiving reward/punishment and those who do not	• Group Receiving Reward: higher attendance rate, high motivation to work, stable employee discipline level. • Group Receiving Punishment: lower attendance rate. In some cases, employees who frequently arrive late or are absent do not show any changes even after receiving punishment.
5.	Trends and patterns of employee attendance	• Stable Attendance Rate: The average attendance reaches around 90%. • Majority of Employees Punctual: The attendance distribution shows a consistent pattern with the majority of employees arriving on schedule. • Employees with High Lateness: There is a small portion of employees with a high rate of lateness, requiring special attention to improve work discipline. • Trend Evaluation: Over a while, some employees are frequently late, necessitating further evaluation regarding the factors influencing punctuality.
6.	Implications and recommendations	• The use of data analytics is necessary to enhance operational efficiency and productivity. • Improved implementation of appropriate and effective rewards can enhance employee attendance. • Evaluation of the punishment system is necessary to ensure effectiveness in disciplining employees. • Implementation of advanced technology such as integration with face recognition systems can enhance accuracy and efficiency in monitoring employee attendance. • Better training and support are needed to enhance understanding and acceptance of attendance policies.

Table 3. Evaluation metrics results for the used ML models (author's elaboration)

Evaluation Metrics	Before Rewards and Punishments			After Rewards and Punishments		
	Model					
	Naïve Bayes	Decision Tree	SVM	Naïve Bayes	Decision Tree	SVM
Accuracy	75%	82%	78%	80%	85%	79%
Precision	72%	79%	78%	78%	82%	76%
Recall	78%	85%	81%	82%	88%	80%
F1-Score	75%	82%	78%	80%	85%	79%

The evaluation results indicate that Decision Tree has the highest performance before the implementation of rewards and punishments with an accuracy of 82%, precision of 79%, recall of 85%, and F1-score of 82%. However, after the implementation of rewards and punishments, there is an improvement in the performance of the Decision Tree, where the accuracy reaches 85%, with precision at 82%, recall at 88%, and an F1-score of 85%. These results indicate that the implementation of rewards and punishments has a positive impact on the ability of the attendance system to predict or classify employee attendance. However, the Naïve Bayes and SVM models also show improvement in performance after the implementation of rewards and punishments, although not as much as that seen in Decision Tree. This suggests that the use of rewards and punishments can enhance the effectiveness of the employee attendance system overall, although, in this study, their impact varies somewhat.

Table 4. Summary of analysis results for the average attendance percentage before and after the implementation of the reward and punishment method in the employee attendance system (author's elaboration)

Indicator	Value N=200	
	Before Rewards and Punishments	After Rewards and Punishments
Total days of work by employees during the conducted research	133 days	75 days
Average duration of lateness	8 minutes	5 minutes
Average frequency of lateness	9 times	4 times
Average attendance rate	86.52%	90.44%
Average absenteeism rate	13.48%	9.56%

Overall statistics of employee attendance

Based on the research findings on the description of employee attendance data, it can be concluded that the overall attendance rate tends to be stable with an average attendance of 90.44% during the examined period. The distribution of attendance shows a consistent pattern with the majority of employees arriving on time according to the company's established work schedule. However, there is a small number of employees who have a higher than average rate of lateness, requiring special attention in efforts to improve work discipline. Additionally, the distribution of lateness also indicates that some employees are consistently late over a certain period, for example, several employees are always late on the first day after a holiday or weekend. This requires further evaluation regarding the factors affecting punctuality on arrival and necessitates some solutions to prevent similar occurrences in the future. In this regard, the lateness of certain employees affects the motivation and focus of other employees, echoing the statement by [17] and [19].

Distribution of attendance and lateness

Based on the findings of this investigation, it can be seen that the attendance and work discipline policies implemented by the company are generally effective in maintaining a high level of attendance among employees. However, there are some points to consider, as there are still a small number of employees who require special attention in terms of work discipline and punctuality. Through these patterns and distributions of attendance and lateness, company management can identify areas that need improvement or implement additional strategies to enhance overall performance and work discipline. This can help create a more productive and efficient work environment for all employees. Additionally, there are several factors influencing attendance lateness among employees, as summarized in Table 5. The influencing factors data were obtained through interviews conducted with all employees from various backgrounds, although in this case, department names and employee names are not mentioned to preserve privacy.

Table 5. Factors influencing employee attendance (author's elaboration)

No.	Influential Factors	Description	Evaluation/Recommendation
1.	Personal issues	Personal issues such as health problems, family needs, or personal conflicts can disrupt employees and affect their attendance.	• Providing health programs and counseling to assist employees in addressing health issues and personal conflicts. • Flexibility in work schedules to allow employees to attend to personal matters.
2.	Economic conditions	Employees may be more inclined to be absent to seek more stable employment elsewhere or due to personal financial issues.	• Offering financial incentives or performance-based bonuses to enhance employee motivation. • Establishing personal finance programs and investment counseling to assist employees in managing their finances more effectively.
3.	Stress	An unpleasant or unsupportive work environment can reduce motivation to attend and contribute.	• Providing mental health programs and counseling support. • Organizing stress management and work-life balance training sessions.
4.	Office environment	Severe traffic congestion or long distances to travel can lead to lateness or absence.	• Building a work culture that emphasizes the importance of work-life balance. • Providing rewards or recognition to employees with good attendance and positive contributions.
5.	Commute/transportation distance	A company culture that supports work-life balance and rewards employee well-being can improve attendance.	• Offering flexibility in work hours or alternative transportation solutions such as company transportation or transportation subsidies. • Introducing remote work or flexible work policies to reduce commuting pressure.
6.	Emergencies	Bad weather, natural disasters, or other emergencies can disrupt employee attendance due to transportation difficulties or the need to focus on personal or family matters.	• Creating emergency plans and clear communication to address emergencies affecting employee attendance. • Providing flexibility in emergency leave policies or special leave for affected employees.
7.	Other factors	• A person's character or lazy attitude can affect employee motivation and discipline, which in turn can affect attendance. • Lack of verbal reprimand from supervisors. • Dismissive and unappreciative nature. • Poor time management. • No motivation to work due to a dull atmosphere.	• Establishing consistent and fair disciplinary policies to address non-compliance. • Issuing warnings to employees who are late. • Providing advice and motivation to improve work performance. • Conducting regular performance evaluations and providing constructive feedback to employees to encourage growth and improvement.

Discussion

Assessing the efficacy of rewards and punishments reveals a positive association between reward administration and employee attendance rates. The findings imply that persons who get prizes are more likely to attend than those who do not receive such incentives. In contrast, a negative link is shown between the administration of fines and attendance rates, with those exposed to disciplinary proceedings having lower attendance inclinations. These findings imply that offering suitable incentives or awards might be an effective motivator for employees to stick to their work schedules and increase their attendance at work. Furthermore, a comparison was made between groups of employees who received rewards or penalties and those who exhibited no significant variation in attendance rates. The group getting prizes consistently had a greater attendance percentage than those who did not receive awards, but the group receiving punishment tended to have a lower attendance rate. These data suggest that rewarding or punishing employees has a considerable influence on their total attendance rate. Thus, it can be argued that offering rewards and punishments is a key factor in encouraging employees to stick to their work schedules and increase their attendance at work. These findings have significant significance for firm management in developing and executing effective attendance management techniques. Understanding their influence enables

management to maximize the use of incentives and punishments as instruments to improve work discipline and overall staff productivity.

Upon analyzing the research results, it is evident that there are numerous notable patterns and trends discernible in the data about employee attendance. Overall, it was found that most employees have a stable attendance rate, but there is variation in the level of lateness among individuals. Attendance records show that most employees follow their work schedules successfully; nonetheless, there is a tiny minority with higher-than-average lateness rates. This tendency shows that efforts to promote work discipline may need to be directed toward these small groups to attain more consistent attendance rates overall. In terms of the effectiveness of incentives and punishments, study findings show that constant giving of awards or bonuses is related to greater employee attendance rates. In contrast, the application of penalties or the withholding of bonuses is linked to lower attendance rates. Overall, our study findings reveal that effective attendance management necessitates a thorough grasp of attendance data patterns and trends, as well as the use of suitable tactics to encourage workers to show up for work regularly. Understanding the influence of various elements such as incentives, penalties, and other variables allows management to take appropriate action to enhance employee attendance and foster a productive and sustainable work environment.

Company implications and recommendations

The research findings have significant implications for the company's HR strategy. To begin, a detailed understanding of patterns and trends in attendance data enables management to identify areas that require special attention in efforts to improve employee discipline and attendance. This conclusion emphasizes the need to employ data analytics to make attendance management decisions that improve operational efficiency and productivity. Furthermore, research on the effectiveness of rewards and penalties has significant implications for regulating attendance rules and practices. Management may consider increasing the use of suitable and effective awards to recognize employees who stick to their work schedules. On the other side, examining the punishment system may result in improvements or tweaks to current penalty policies to verify they are effective in penalizing employees who are prone to late or absenteeism. The organization may consider many strategic actions when making recommendations for upgrading or strengthening the attendance system. First, incorporating more current technology into attendance systems, such as facial recognition integration, offers the potential to improve the accuracy and efficiency of employee attendance tracking. Furthermore, giving managers and employees greater training and support in understanding and using the attendance system can help boost compliance and acceptance of current attendance standards. Thus, the recommendations seek to improve HR management by using the study's findings to improve the performance and efficacy of the organization's attendance system. With the implementation of these measures, the firm hopes to establish a more productive, efficient, and employee-focused work environment overall.

CONCLUSION

Employee presence patterns produce a steady presence rate of about 90%. Presence distribution follows a similar pattern, with most employees coming on time. Nonetheless, a tiny percentage of employees are frequently late, necessitating extra attention to promote work discipline. Assessment of presence trends suggests that over time, some employees tend to be consistently late, requiring further evaluation of factors affecting their regularity over time. Regarding trends in the use of reward and punishment systems, research finds that the management's use of the reward system tends to be more frequent than the use of punishment system. However, analysis of employee attendance data reveals that there is no significant correlation between reward giving and increased employee attendance. This may indicate that the reward approach alone is not sufficiently effective in influencing attendance. On the other hand, research also found that when punishment is imposed, such as reduced bonuses or certain sanctions for employees who are often absent for no apparent reason, leads to a more significant increase in employee attendance. It shows that using a penalty system rather than a reward system might be more successful in encouraging attendance. The efficacy of the reward and punishment system may be inferred that the application of ML approaches in evaluating employee presence data has a considerable beneficial influence on the efficiency of their attendance management. Accuracy in predicting patterns of attendance increased to 20% after using group algorithms. Besides, the implementation of rewards and penalties has a positive impact on employee attendance. In this case, there is an approximately 4% increase in the average employee attendance, rising from an attendance rate of 86.52% to 90.44%). For comparative analysis, the results revealed that the group of employees receiving rewards, 60% showed no significant difference in attendance rates, while 40%

showed a higher rate of attendance. Meanwhile, within the group receiving punishment, 10% indicated no change, while 90% experienced a substantial increased in absenteeism.

REFERENCES

[1] M. N. Kamil, B. M. Musah, and M. Zakari, "The Impact of Biometric Time and Attendance System on Workforce Management Outcomes: The Moderating Role of Managerial Commitment in the Service Sector in Northern Ghana," *International Journal of Business and Technology Management*, Sep. 2023, doi: 10.55057/ijbtm.2023.5.3.37.

[2] G. Johns, "Attendance Dynamics at Work: The Antecedents and Correlates of Presenteeism, Absenteeism, and Productivity Loss," *J Occup Health Psychol*, vol. 16, no. 4, pp. 483–500, Oct. 2011, doi: 10.1037/A0025153.

[3] J. Severin, M. Svensson, and M. Akerstrom, "Cost–Benefit Evaluation of an Organizational-Level Intervention Program for Decreasing Sickness Absence among Public Sector Employees in Sweden," *Int J Environ Res Public Health*, vol. 19, no. 5, Mar. 2022, doi: 10.3390/ijerph19052998.

[4] G. O. Anyalewechi and C. E. C. Ezeagwu, "Securing Organizational Operation: An Electronic Gate System Integrating Facial Recognition for Attendance Tracking and Access Control," *Interdisciplinary Journal of Agriculture and Environmental Sciences (IJAES)*, vol. 10, no. 3, pp. 1–10, Aug. 2023, doi: 10.5281/ZENODO.8234103.

[5] A. Ardebili, A. Latifian, C. F. Aziz, R. H. BinSaeed, S. M. Alizadeh, and E. V. Kostyrin, "A Comprehensive and Systematic Literature Review on the Employee Attendance Management Systems Based on Cloud Computing," *Journal of Management & Organization*, vol. 29, no. 4, pp. 679–696, 2023, doi: 10.1017/JMO.2022.63.

[6] S. Ndayisaba, "The attendance alert based biometric system for employees using fingerprint: a case of hope Africa university, Bujumbura-Burundi," Mar. 2023, doi: 10.58694/20.500.12479/2453.

[7] M. S. Rahman, R. Ahmmed, M. A. Sarker, K. M. Rumman, A. Rahman, and A. Sarker, "Fingerprint Based Biometric Attendance System Section A-Research paper Eur," *Chem. Bull*, vol. 2023, no. S3, pp. 184–190, doi: 10.31838/ecb/2023.12.s3.026.

[8] M. Suriya *et al.*, "Face Recognition Attendance System," *2023 9th International Conference on Advanced Computing and Communication Systems, ICACCS 2023*, pp. 2042–2047, 2023, doi: 10.1109/ICACCS57279.2023.10113114.

[9] R. Memane, P. Jadhav, J. Patil, S. Mathapati, and A. Pawar, "Attendance Monitoring System Using Fingerprint Authentication," *2022 6th International Conference on Computing, Communication, Control and Automation, ICCUBEA 2022*, 2022, doi: 10.1109/ICCUBEA54992.2022.10010791.

[10] K. Kumari, S. Barkat Ali, N. Un Nisa Khan, and J. Abbas, "Examining the Role of Motivation and Reward in Employees' Job Performance through Mediating Effect of Job Satisfaction: An Empirical Evidence," *International Journal of Organizational Leadership*, vol. 10, no. 4, pp. 401–420, Dec. 2021, doi: 10.33844/IJOL.2021.60606.

[11] W. Cai, S. Gallani, and J. E. Shin, "Incentive Effects of Subjective Allocations of Rewards and Penalties," *https://doi.org/10.1287/mnsc.2022.4501*, vol. 69, no. 5, pp. 3121–3139, Aug. 2022, doi: 10.1287/MNSC.2022.4501.

[12] A. M. Abdullah, A. E. Mohammed, and A. M. Abduljabar, "Electronic Attendance System Impact on Healthcare Employees' Performance and Economic Impact in Saudi Arabia," *Saudi Journal of Business and Management Studies*, vol. 8, no. 11, pp. 250–256, Nov. 2023, doi: 10.36348/sjbms.2023.v08i11.001.

[13] Y. Suale, M. N. Kamil, B. M. Musah, and M. Zakari, "The Impact of Biometric Time and Attendance System on Workforce Management Outcomes: The Moderating Role of Managerial Commitment in the Service Sector in Northern Ghana," *International Journal of Business and Technology Management*, Sep. 2023, doi: 10.55057/ijbtm.2023.5.3.37.

[14] P. Rastogi, P. Saravanan, G. H. Kerinab Beenu, I. Kaur, R. J. Anandhi, and S. Senthilkumar, "Analysis Face Recognition based Systems for Employees Attendance Machine Learning,"

Proceedings of the 2023 2nd International Conference on Augmented Intelligence and Sustainable Systems, ICAISS 2023, pp. 515–520, 2023, doi: 10.1109/ICAISS58487.2023.10250622.

[15] M. F. A. M. Noor, A. F. Ibrahim, and M. N. F. Jamaluddin, "Development of Employee Attendance Management System using Flutter," *Journal of Computing Research and Innovation*, vol. 8, no. 2, pp. 178–188, Sep. 2023, doi: 10.24191/JCRINN.V8I2.369.

[16] K. Ranasinghe *et al.*, "Advances in Integrated System Health Management for mission-essential and safety-critical aerospace applications," *Progress in Aerospace Sciences*, vol. 128, p. 100758, Jan. 2022, doi: 10.1016/J.PAEROSCI.2021.100758.

[17] H. de la Nuez, J. Nieves, and J. Osorio, "Neuroleadership: Affective Experiences in the Workplace and their Tnfluence on Employees' Evaluative Judgements," *Int J Hosp Manag*, vol. 114, p. 103554, Sep. 2023, doi: 10.1016/J.IJHM.2023.103554.

[18] E. H. Woods, Y. Zhang, E. C. Roemer, K. B. Kent, M. F. Davis, and R. Z. Goetzel, "Addressing Psychosocial, Organizational, and Environmental Stressors Emerging From the COVID-19 Pandemic and Their Effect on Essential Workers' Mental Health and Well-being: A Literature Review," *J Occup Environ Med*, vol. 65, no. 5, pp. 419–427, May 2023, doi: 10.1097/JOM.0000000000002802.

[19] F. C. Shih, S. C. J. Yeh, and W. L. Hsu, "Abusive supervision and employee well-being of nursing staff: Mediating role of occupational stress," *J Adv Nurs*, vol. 79, no. 2, pp. 664–675, Feb. 2023, doi: 10.1111/JAN.15538.

[20] D. J. Dwyer and D. C. Ganster, "The Effects of Job Demands and Control on Employee Attendance and Satisfaction," *J Organ Behav*, vol. 12, no. 7, pp. 595–608, Dec. 1991, doi: 10.1002/JOB.4030120704.

[21] I. Litchfield and P. Hinckley, "Factors influencing improved attendance in the UK fire service," *Occup Med (Chic Ill)*, vol. 66, no. 9, pp. 731–736, Dec. 2016, doi: 10.1093/OCCMED/KQW156.

[22] C. Brega, S. Briones, J. Javornik, M. León, and M. Yerkes, "Flexible Work Arrangements for Work-life Balance: A Cross-national Policy Evaluation from a Capabilities Perspective," *International Journal of Sociology and Social Policy*, vol. 43, no. 13–14, pp. 278–294, 2023, doi: 10.1108/IJSSP-03-2023-0077/FULL/PDF.

[23] T. Ferdous, M. Ali, and E. French, "Use of Flexible Work Practices and Employee Outcomes: The Role of Work–life Balance and Employee Age," *Journal of Management & Organization*, vol. 29, no. 5, pp. 833–853, Sep. 2023, doi: 10.1017/JMO.2020.44.

[24] A. Khan, A. Khan, T. A. Shah, M. Nisar Khattak, and R. Abukhait, "Management's internal governance policies on flexible work practices and the mediating lens of work life enrichment – Outcome for employee work engagement and organizational attractiveness," *Journal of Organizational Effectiveness*, vol. ahead-of-print, no. ahead-of-print, 2023, doi: 10.1108/JOEPP-02-2023-0059/FULL/XML.

[25] Z. Gao, "No Kidding: The Moderating Role of Childcare Responsibility on the Relationship Between Perceived Work-Life Balance Policy Culture and Job Outcomes," *Master's Theses*, Jan. 2023, doi: https://doi.org/10.31979/etd.esm3-krku.

[26] E. E. Kossek, B. A. Lautsch, M. B. Perrigino, J. H. Greenhaus, and T. J. Merriweather, "Work-life Flexibility Policies: Moving from Traditional Views Toward Work-life Intersectionality Considerations*," vol. 41, pp. 199–243, Sep. 2023, doi: 10.1108/S0742-730120230000041008.

[27] S. J. Blithe, "Work-Life Balance and Flexible Organizational Space: Employed Mothers' Use of Work-Friendly Child Spaces," *https://doi.org/10.1177/08933189231152454*, vol. 37, no. 4, pp. 821–845, Jan. 2023, doi: 10.1177/08933189231152454.

[28] P. Babu Jha *et al.*, "An Automated Attendance System Using Facial Detection and Recognition Technology," *Apex Journal of Business and Management*, vol. 01, no. 01, pp. 103–120, 2023, doi: 10.61274/apxc.2023.v01i01.008.

[29] T. V. Dang, "Smart Attendance System based on improved Facial Recognition," *Journal of Robotics and Control (JRC)*, vol. 4, no. 1, pp. 46–53, Feb. 2023, doi: 10.18196/JRC.V4I1.16808.

[30] T. Tran, “Automatic attendance system in the workplace based on face recognition in Real-Time using the Principal Component Analysis method and Eigenface technique,” 2022, Accessed: Apr. 28, 2024. [Online]. Available: http://www.theseus.fi/handle/10024/784021

[31] J. Pradyumna, T. Khan, and K. Kumar, “Smart Attendance System using Face Recognition.” [Online]. Available: www.ijfmr.com

[32] Nitish, S. P. Singh, and S. Sagar, “Surveillance-Based Security System for Hostel Safety Measurement using RFID and Image Processing Technique,” *2023 International Conference on Communication, Security and Artificial Intelligence, ICCSAI 2023*, pp. 30–35, 2023, doi: 10.1109/ICCSAI59793.2023.10421445.

[33] C. S. Gode, A. S. Khobragade, C. Thanekar, O. Thengadi, and K. Lakde, “Face Recognition-Based Attendance System,” *Advances in Intelligent Systems and Computing*, vol. 1439, pp. 159–166, 2023, doi: 10.1007/978-981-19-9819-5_12.

[34] A. Shukla, A. K. Shukla, A. Shukla, and R. Singh, “Neural Networks Based Face Recognition System for Biometric Security,” *Indian Journal of Engineering*, vol. 20, pp. 16–1640, 2023, doi: 10.54905/disssi/v20i53/e16ije1640.

[35] D. C. Hamilton, W. J. Mckibbin, S. Munkeby, and J. A. Straub, “A QUANTITATIVE STUDY ON USER ACCEPTANCE FOR BIOMETRIC PRIVACY, SECURITY, AND CHALLENGES IN DATA COLLECTION AND STORAGE,” 2022.

[36] P. Holland and T. L. Tham, “Workplace biometrics: Protecting employee privacy one fingerprint at a time,” *https://doi.org/10.1177/0143831X20917453*, vol. 43, no. 2, pp. 501–515, Apr. 2020, doi: 10.1177/0143831X20917453.

[37] H. F. Neo and C. C. Teo, “Biometrics in Tourism: Issues and Challenges,” *Handbook of e-Tourism*, pp. 1835–1849, Jan. 2022, doi: 10.1007/978-3-030-48652-5_137.

[38] C. Del Rosso, “Access Granted: An Examination of Employee Biometric Privacy Laws and a Recommendation for Future Employee Data Collection,” *Journal of Law, Economics & Policy*, vol. 18, 2023, Accessed: Apr. 28, 2024. [Online]. Available: https://heinonline.org/HOL/Page?handle=hein.journals/jecoplcy18&id=30&div=&collection=

[39] V. Gaikwad, D. Rathi, V. Rahangdale, R. Pandita, K. Rahate, and R. S. Rajpurohit, “Design and Implementation of IOT Based Face Detection and Recognition,” *Computing & Intelligent Systems*, pp. 923–933, 2024, doi: 10.56155/978-81-955020-2-8-78.

[40] A. Gupta, S. Sriram, and V. Nivethitha, “Harnessing Diversity in Face Recognition: A Voting and Bagging Ensemble Approach,” *2024 International Conference on Automation and Computation (AUTOCOM)*, pp. 249–255, Mar. 2024, doi: 10.1109/AUTOCOM60220.2024.10486188.

[41] O. Gacutan Bangayan, R. Bautista Rivera, and M. Bulan Asis, “Timekeeping and Immediate Monitoring of Employees by Consistently Advocating Time Consciousness and Honesty Using Enhanced Attendance Monitoring System,” *Pertanika J. Sci. & Technol*, vol. 31, no. 1, p. 292, 2023, doi: 10.47836/pjst.31.1.18.

[42] V. Rohini, M. Sobhana, and C. S. Chowdary, “Attendance Monitoring System Design Based on Face Segmentation and Recognition,” *Recent Patents on Engineering*, vol. 17, no. 2, Apr. 2022, doi: 10.2174/1872212116666220401154639.

[43] V. Mallikarjunaradhya, A. Ganesh, J. Mistry, and T. Kiruthiga, “The smart analysis of cell damage and cancerous prediction using information clustering model,” *2023 2nd International Conference on Smart Technologies for Smart Nation, SmartTechCon 2023*, pp. 870–875, 2023, doi: 10.1109/SMARTTECHCON57526.2023.10391822.

[44] M. Ozcan and S. Peker, “A classification and regression tree algorithm for heart disease modeling and prediction,” *Healthcare Analytics*, vol. 3, p. 100130, Nov. 2023, doi: 10.1016/J.HEALTH.2022.100130.

[45] I. Adeoye, “Unveiling Tomorrow’s Success: A Fusion of Business Analytics and Machine Learning for Employee Performance Prediction,” *SSRN Electronic Journal*, Feb. 2024, doi: 10.2139/SSRN.4729244.

[46] Y. Zhao, C. Zhang, Y. Zhang, Z. Wang, and J. Li, “A review of data mining technologies in building energy systems: Load prediction, pattern identification, fault detection and diagnosis,” *Energy and Built Environment*, vol. 1, no. 2, pp. 149–164, Apr. 2020, doi: 10.1016/J.ENBENV.2019.11.003.

[47] X. Tian, R. Pavur, H. Han, and L. Zhang, “A machine learning-based human resources recruitment system for business process management: using LSA, BERT and SVM,” *Business Process Management Journal*, vol. 29, no. 1, pp. 202–222, Jan. 2023, doi: 10.1108/BPMJ-08-2022-0389/FULL/XML.

[48] M. Mustaqeem and M. Saqib, “Principal component based support vector machine (PC-SVM): a hybrid technique for software defect detection,” *Cluster Comput*, vol. 24, no. 3, pp. 2581–2595, Sep. 2021, doi: 10.1007/S10586-021-03282-8/TABLES/7.

[49] A. Rifan Rudiyanto and M. Arief Soeleman, “Performance of the Decision Tree Algorithm in the Classification of Edible and Poisonous Mushrooms with Information Gain Optimization,” *Scientific Journal of Informatics*, vol. 10, no. 4, 2023, doi: 10.15294/sji.v10i4.47864.

[50] A. Fahmi Limas, R. Rosnelly, and A. Nursie, “A Comparative Analysis on the Evaluation of KNN and SVM Algorithms in the Classification of Diabetes,” *Scientific Journal of Informatics*, vol. 10, no. 3, p. 251, 2023, doi: 10.15294/sji.v10i3.44269.

[51] A. Adimas and S. Y. Irianto, “Image Sketch Based Criminal Face Recognition Using Content Based Image Retrieval,” *Scientific Journal of Informatics*, vol. 8, no. 2, pp. 176–182, Nov. 2021, doi: 10.15294/sji.v8i2.27865.

[52] E. Z. Astuti, C. A. Sari, E. H. Rachmawanto, and R. R. Ali, “Comparative Study of Machine Learning Algorithms for Performing Ham or Spam Classification in SMS,” *Scientific Journal of Informatics*, vol. 11, no. 1, pp. 177–186, Feb. 2024, doi: 10.15294/sji.v11i1.47364.

[53] M. Ibtasam, “Accuracy Measurements and Decision Making by NaÃ¯ve Bayes and Forward Chaining Method to Identify the Malnutrition Causes and Symptoms,” *Scientific Journal of Informatics*, vol. 8, no. 2, pp. 320–324, Nov. 2021, doi: 10.15294/sji.v8i2.29317.

[54] I. Lohrasbinasab, A. Shahraki, A. Taherkordi, and A. Delia Jurcut, “From statistical- to machine learning-based network traffic prediction,” *Transactions on Emerging Telecommunications Technologies*, vol. 33, no. 4, Apr. 2022, doi: 10.1002/ett.4394.

[55] H.-G. Kim, D.-Y. Lee, S.-Y. Jeong, H. Yoo, and W.-K. Hong, “Machine Learning-Based Method for Prediction Virtual Network Function Resource Demans,” *IEEE Conference on Network Softwarization (NetSoft)*, 2019.

[56] I. Branescu, R. I. Ciobanu, C. Dobre, and C. Mavromoustakis, “Decentralized Machine Learning for Face Recognition,” *Proceedings - 2023 22nd International Symposium on Parallel and Distributed Computing, ISPDC 2023*, pp. 1–8, 2023, doi: 10.1109/ISPDC59212.2023.00010.

[57] S. D. Rana, “Smart Attendance: An Automated Attendance Management System Using Machine Learning Techniques,” *Mathematical Statistician and Engineering Applications*, vol. 70, no. 2, pp. 1285–1294, Feb. 2021, doi: 10.17762/MSEA.V70I2.2320.

[58] L. Liu, Q. Mei, A. Skogstad, J. Wu, S. Liu, and M. Wang, “Linking Safety-Specific Leader Reward and Punishment Omission to Safety Compliance Behavior: The Role of Distributive Justice and Role Ambiguity,” *Front Public Health*, vol. 10, p. 841345, Mar. 2022, doi: 10.3389/FPUBH.2022.841345/BIBTEX.

[59] D. Dwi Aulia and N. Nurahman, “Comparison Performance of K-Medoids and K-Means Algorithms In Clustering Community Education Levels,” *Jurnal Nasional Pendidikan Teknik Informatika (JANAPATI)*, vol. 12, no. 2, pp. 273–282, 2023, doi: 10.23887/janapati.v12i2.59789.

[60] R. Clark *et al.*, “Understanding Collaborative Implementation Between Community and Academic Partners in a Complex Intervention: a Qualitative Descriptive Study,” *BMC Health Serv Res*, vol. 23, no. 1, pp. 1–11, Dec. 2023, doi: 10.1186/S12913-023-09617-Y/TABLES/3.

[61] D. Pollock *et al.*, “Recommendations for the Extraction, Analysis, and Presentation of Results in Scoping Reviews,” *JBI Evid Synth*, vol. 21, no. 3, pp. 520–532, Mar. 2023, doi: 10.11124/JBIES-22-00123.

[62] M. Weber, M. Beutter, J. Weking, M. Böhm, and H. Krcmar, "AI Startup Business Models: Key Characteristics and Directions for Entrepreneurship Research," *Business and Information Systems Engineering*, vol. 64, no. 1, pp. 91–109, Feb. 2022, doi: 10.1007/S12599-021-00732-W/TABLES/6.

[63] R. J. Acosta and R. A. Irizarry, "A Flexible Statistical Framework for Estimating Excess Mortality," *Epidemiology*, vol. 33, no. 3, pp. 346–353, May 2022, doi: 10.1097/EDE.0000000000001445.